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Original Article

Internet of Things: An Approach to Enhance Healthcare Quality in Nigeria

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Abstract *- Internet of Things (IoT) would be a game-changer for the healthcare sector in Nigeria as it can sense, process, and communicate patients' biological and physical parameters with caregivers. The study aims to investigate how the deployment of IoT in the Nigerian healthcare system can help improve the quality of healthcare. The study adopts a mix of qualitative and quantitative methods of research to gather the needed data. The findings reveal that deploying IoT in the Nigerian healthcare sector has many benefits, including easy access to patients' records regardless of time and location, minimizing medical errors, better decision-making, and lower treatment costs. However, privacy and security are found to be the major threats, while the requirements for constant power supply and high-speed Internet connection are the major challenges. Since the problems relating to threats and challenges of deploying IoT in the Nigerian healthcare industry can be mitigated based on the study suggestions, we therefore strongly recommend the adoption and implementation of IoT in the Nigerian healthcare system, which has highlighted the benefits. This development would greatly enhance quality healthcare in the Nigerian healthcare industry and benefit healthcare stakeholders and researchers.*

Keywords *- Healthcare, IoT, Remote healthcare monitoring, Sensors, Smart hospital.*

I. INTRODUCTION

A. Overview

The traditional healthcare approach in Nigeria is unable to satisfy the needs of everyone due to its large population. Medical services are expensive and inaccessible to everyone based on this approach. One of the goals of a smart healthcare system is to enlighten and inform individuals regarding their medical conditions and health [1]. Users can handle some of their emergencies with the help of smart healthcare. The focus is on enhancing the quality of the product and the user experience. It allows for remote patient monitoring and lowers healthcare expenditures [2]. It also allows caregivers to increase their services without being limited by location or time [3]. With the rising trend toward smart cities, residents will have access to a more effective smart healthcare system.

As contained in the study of [4], the National Sanitation Foundation (NSF) issued a report in 2002 in which the major focus is on the intersection of nanotechnology with information and communication technologies (ICT). Combining these technologies improves people's quality of life. Device detection technologies, embedded systems, sensors, wireless networks, and nanotechnology are all utilized to link things on the Internet, ensuring that everything has a unique identity [5]. IoT, according to [6], refers to a set of technologies that enable connectivity between a variety of devices. Numerous applications based on IoT have been created for diverse purposes in the healthcare sector. Furthermore, the healthcare IoT is a multifaceted system including computer science, medicine, microelectronics, health systems, and other disciplines [7].

This technology plays a significant role in monitoring patients remotely in hospitals and, most significantly, at home. By detecting and avoiding dangerous illnesses and disorders, remote patient monitoring offers significant potential for improving healthcare quality and lowering healthcare expenses [8]. The healthcare system in Nigeria is now very costly than before because hospitalization is required by most patients for treatment. These problems can be solved with the deployment of IoT technologies that can remotely monitor patients. This would decrease expenses in healthcare and enable health-related problems to be addressed when they are not critical by collecting and sending real-time patient health data to caregivers [9]. This enhancement requires the Nigerian healthcare industry to urgently adopt and integrate IoT into the healthcare system. This would undoubtedly improve the quality of people's life.

B. Aim and Objectives

Integrating IoT into the Nigerian healthcare system would offer solutions to the traditional approach to healthcare, such as communication in real-time to assist caregivers in delivering quality care to patients. Therefore, the major aim and objectives of this study are to

- Investigate how the quality of healthcare in the Nigerian healthcare industry can be improved using IoT.

- Examine the economic benefits of IoT and underline its importance in the Nigerian healthcare industry.
- Pinpoint the barriers of IoT adoption and implementation in the Nigerian healthcare system.
- Offer measures to mitigate IoT adoption barriers and propose the integration of IoT into the Nigerian healthcare system.

C. Problem Statement

Traditional approaches to handling patient information in the healthcare industry have several problems, including time and mistake proneness, a lack of backups and security, decentralized storage, and expensive costs [10]. Because of poor storage, sensitive information about patients might be leaked, forgotten, destroyed, or acquired by unauthorized people resulting in a breach of confidentiality and data privacy which is harmful to patients [11]. These difficulties pose a substantial risk to their safety and welfare [12]. As a result, [13] argued for a system that focuses on maintaining patient confidentiality and anonymity to unauthorized persons.

Furthermore, the time it takes healthcare personnel to write medical and cares records for patients with chronic diseases using handwritten processes renders the records prone to mistakes. When aggregating a patient's data, these records are occasionally mismanaged, resulting in discrepancies. The amount of storage necessary to preserve these handwritten documents is enormous, and most healthcare facilities lack it. This meant that documents were frequently destroyed without regard for their legal implications or any future use in policy or study.
Similarly, as compared to other health issues, the expense of treating individuals living with chronic disease informally is substantially greater [14]. As a result of the enormous resources required to support the patient's expenditures, efforts to ensure that all individuals living with the chronic disease receive quality and appropriate treatment rise proportionately with costs from the patient's family or government [15].

Therefore, integrating IoT into the Nigerian healthcare system with centralized storage would assist in minimizing the time it takes to fill out records while also lowering treatment and service costs [16]. However, there are several obstacles in the way of attaining this goal, such as lack of reliable Internet connection, lack of constant power supply, and training requirements. Nevertheless, the findings in this study would enable health practitioners, stakeholders, and policymakers to make informed decisions about IoT adoption and implementation in the Nigerian healthcare system.

D. Research Questions

The following are some of the questions that this research would address:

- What are the areas of applications of IoT in the Nigerian healthcare system?
- How would IoT benefit the Nigerian healthcare system?
- What are the barriers to the Nigerian healthcare system embracing and deploying IoT?
- What are the possibilities that the IoT will enhance the quality of healthcare in Nigeria?
- What dangers exist while utilizing IoT in the Nigerian healthcare sector?

These research questions are addressed in section 4 of this study, thus forming the study outcome.

E. Organisation of Work

The following sections make up the remainder of this paper: Section 2 reviewed the literature; in section 3, the research methodology used in this study is discussed; the major search results are discussed in section 4; while section 5 wraps up the research and
makes recommendations.

II. LITERATURE REVIEW

As contained in the studies of [17] and [18], the healthcare industry in Nigeria needs to incorporate the IoT to enhance the present healthcare system due to an increase in the number of people seeking healthcare services, growing prices, and pressure to innovate.

The IoT, according to Lanre Kolade, managing director of Vodacom Business Nigeria, "is a tremendous instrument to properly solve Nigeria's healthcare issues" [19]. Kolade said IoT might be used to improve healthcare access by expanding the scope of care services to rural and hard-to-reach regions and ensuring that vital medications are available where and when they are required during a keynote speech at the Lagos Chamber of Commerce and Industry's Information Communications Technology and Telecommunications (ICTEL) Expo, 2017. According to him, this technology is enabling linked medical services that allow healthcare professionals to diagnose and consult with patients and first responders from anywhere.

The major problem for Nigeria's healthcare system, according to a recent study from the World Health Organization's Global Healthcare Workforce Alliance, is insufficient production and inequitable distribution of health professionals, with a ratio of 1.95 health workers per ten thousand inhabitants [20]. This implies that the number of people needing healthcare services outnumbers the number of qualified personnel available, and individuals in need may be a long way from the nearest hospital or clinic.

Kolade went on to say that the expense of managing global populations, as well as the rising frequency of chronic diseases, is placing Nigerian governments under a lot of strain. He added that IoT technology becomes crucial to driving healthcare efficiency, where governments and industry bodies may utilize large-scale data sets acquired by IoT to analyze treatment efficacy, track disease transmission, and comprehend macro patterns in population health to inform policy decisions.

In Nigeria, the IoT is significant to the development of a digital healthcare system [21]. Technology allows one to link a wide range of assets, from heart monitors to chiller cabinets [22]. These devices have sensors that enable their surroundings to be monitored as well as a network link that allows them to interact [23].

The research of [24] and [25] reported that Vodacom and the Kaduna State Government had announced the start of SMS for Life 2.0, a healthcare service in the state that is based on mobile technology. Its goal is to enhance healthcare delivery to residents who use public health services by monitoring drug stock levels and increasing the availability of important medications. The program, which is a public-private collaboration between the Kaduna State Ministry of Health and Novartis, has Vodacom as its technology partner. Vodacom has completed the training and implementation of SMS for Life 2.0 in Kaduna, with the platform now being used by over 250 facilities. This program will be implemented in each of the thirty-six states in Nigeria to facilitate quality healthcare delivery.

III. RESEARCH METHODOLOGY

A mix of qualitative and quantitative methods of research as advocated by [26] was employed to gather the needed data for the study. Various areas, including computer science, healthcare, and medical informatics, have researched the adoption and implementation of IoT in the healthcare industry. As a result, published research articles are dispersed among several databases. To construct a thorough bibliography for a research paper on IoT integration in the Nigerian healthcare system, a few prominent electronic resources were suggested. Google Scholar, IEEE, Science Direct, Springer, Elsevier, Wiley, Scopus, and Emerald were the eight digital databases used. A search was conducted on healthcare IoT implementation-related literature published between 2000 and 2021. In addition, studies were found using the following search terms: healthcare, IoT, remote healthcare monitoring, sensors, smart hospital, and their impacts. Abstracts, introductions, and conclusions of the articles were reviewed during the research selection process. To find publications that were more relevant to the study topics, inclusion and exclusion criteria were used. As a result, the following criteria for picking the most relevant publications were established:

- Considering IoT adoption and implementation in healthcare settings.
- Examining the key barriers to the adoption and implementation of IoT in the healthcare industry.
- Addressing the importance and economic benefits of IoT in the healthcare sector.
- Examining the chances of improving healthcare quality through IoT.
- Examining the dangers that exist while utilizing IoT in healthcare?

Also, evaluation of the following exclusion criteria was carried out:

- Book chapters, doctoral or master's theses, and other forms of literature reviews.
- Papers on IoT adoption and implementation for other objectives beyond healthcare, such as aquaculture, agriculture, road conditions, traffic, urban management, smart city, home entertainment, tourism, smart sport, and smart environment.
- Abstracts or papers that were not accessible. The relevant data were obtained from the publications in the final stage. The following information was retrieved for each paper: publication year, study type, IoT adoption and implementation in the healthcare industry, barriers to the adoption and implementation of IoT in the healthcare sector, possibilities of improving the healthcare system through IoT, and main application area of IoT in healthcare.

IV. RESEARCH OUTCOME

This section addresses the research questions, thus forming the study outcome as related to the deployment of IoT in the Nigerian healthcare system. SWOT (Strength, Weaknesses, Opportunities, Threats) analysis is used to answer research questions 2, 3, 4, and 5. As contained in the research of [27], SWOT analysis is a tactical planning approach for evaluating the project's strengths, weaknesses, opportunities, and threats. SWOT analysis is used in this study to determine the elements that are favorable and unfavorable to achieving the project's goal. SWOT's main purpose, according to [28], is to aid a complete understanding of all aspects that may have an impact on strategic planning and decision-making, which is a goal that can be applied to almost any sector. This study suggests the deployment of IoT in the Nigerian healthcare system to enhance healthcare quality. However, before doing so, the healthcare industry must first understand the strengths, weaknesses, opportunities, and threats associated with integrating IoT into the system.

A. Research Question 1: What are the Areas of Applications of IoT in the Nigerian healthcare industry?

[29] inform that IoT technology will be widely used in the healthcare industry in the nearest future. The healthcare sector, according to [30], is continuously looking for innovative methods to offer services while lowering costs and increasing quality; as a result, this sector's reliance on IoT technology will grow. Patients are better able to follow self-care principles because of the usage of these technologies, which leads to greater satisfaction for the patient and better management of self. Also, [31] reported that systems based on IoT can be utilized for monitoring physiological data of patients who require constant care remotely. The convergence of diverse IoT designs has recently enabled the development of smart healthcare systems [32]. Solutions based on IoT may be useful in creating a complete system with the connectivity of heterogeneous items to acquire a whole picture of a patient's state of health. The primary areas that IoT could be applied in the Nigerian healthcare system are described in this section.

a) Home Healthcare

People's life expectancy has improved, according to the World Health Organization (WHO) study on aging and disability, and it is predicted that most people will survive above the age of 60 in Nigeria [33]. [34] reported that chronic illnesses, disability, and hospitalization are more common in the elderly. According to the researchers, the delivery of healthcare services would be converted into a home-based hospital and home care services in the nearest future. The technological revolution affects every area of a patient's life, including emergency management, vital sign monitoring, stroke rehabilitation, medication administration, and telemedicine [35]. The study of [36] found that IoT-based home healthcare services are one of the potential options for overcoming the challenges of population aging in Nigeria.

b) Mobile and Electronic Health

According to [37], the rising use of IoT technologies is highlighted by the communication devices development like smartphones along with their incorporation with numerous kinds of sensors. The software program collects physiological data from the human body using several wearable sensors. These signals are then securely sent to healthcare facilities. Signals in brief messages can inform healthcare workers about medical emergency facilities and aid them in taking appropriate measures, depending on the scenario [38].

c) Hospital management

Responsibilities in hospital administration have been established, such as preventing hospital infections, establishing a comprehensive strategy for patient education, managing emergency circumstances, and logistical systems [39]. The research of [40] named Sensors, ZigBee, RFID, and NFC as examples of IoT-based technologies that can help hospitals address logistical challenges. This revolution has the potential to improve hospital supply chain management by intelligently linking data, processes, and people. For instance, IoT innovations can help the system of vaccine distribution with technological development and support, and they will have an impact on how the leaders of the vaccine supply chain get the needed information to enhance their services [41].

B. Research Question 2: How would the deployment of IoT benefit the Nigerian healthcare system?

This section examines the strengths and benefits of the deployment of IoT in the Nigerian healthcare system. According to [42], the Nigerian healthcare system suffers from a scarcity of resources and a high cost of service, and these could be addressed through the integration of IoT into the system. There would be several benefits for using IoT in the Nigerian healthcare sector, and the essential benefit is that IoT guarantees easy access to a patient's records irrespective of time and location, which fosters more collaboration between caregivers and patients, resulting in improved patient care [43]. Also, [44] inform that the outcomes of treatment may be considerably improved or maximized because of the precise data collected by IoT healthcare devices which allows for informed decisions. Mistakes on the side of caregivers and health facilities would be reduced since patient information can be promptly measured and communicated to a panel of healthcare practitioners or cloud platforms. Moreover, AI-driven algorithms operating on these IoT devices would also assist in making intelligent decisions or recommendations based on available data [45].

Lesser costs, according to [46], are another significant benefit for the deployment of IoT in the Nigerian healthcare system. This is because patients with non-critical issues can sit at home while IoT devices monitor and communicate all vital data to the healthcare institution, resulting in fewer stays in the hospital and visits by the doctor. Furthermore, healthcare institutions would be able to enhance illness management by using extensive data collected from a variety of IoT devices. Real-time data would be received for decision making than ever before, thus enhancing the quality of healthcare in the Nigerian healthcare system [47]. Nevertheless, there are several barriers to overcome for the effective integration of IoT in the Nigerian healthcare system.

C. Research Question 3: What are the barriers to the Nigerian healthcare system embracing and deploying IoT?

This section examines the weaknesses and barriers of the deployment of IoT in the Nigerian healthcare system. There are several aspects to consider before the integration of IoT into the Nigerian healthcare system, thus making its deployment a difficult task. Many hospitals in Nigeria cannot implement IoT because they lack a reliable Internet connection, making healthcare IoT adoption extremely hard [48]. Internet access is a prerequisite for connecting IoT devices and using the service. Therefore IoT for the healthcare industry would be impossible to deploy without it. The key barriers to the integration of IoT in the healthcare industry, according to [49], include requirements for constant power supply, high-speed Internet connection, training necessities, difficulty to integrate with local software, unable to control the quality of service and availability, lack of physical data control, and development of application and deployment.

D. Research Question 4: What are the possibilities that the IoT will enhance the quality of healthcare in Nigeria?

This section examines the opportunities for the deployment of IoT in the Nigerian healthcare system. [50] inform that IoT in the healthcare industry can provide possibilities for healthcare professionals to learn new technologies, users may access the most up-to-date technologies, provide users with cutting-edge services, and problems are solved in a modern and timely manner without disrupting hospital services.

The Nigerian healthcare sector would experience a boom and become more advanced by integrating IoT into the system. The growth of IoT devices in the healthcare sector would assist caregivers in delivering better experiences for clients and patients, improved patient outcomes, and enhanced work conditions for medical professionals [51]. The Nigerian healthcare sector would acquire new insights into medical settings, patient care, and treatment choices as more devices and data become available. Through data access, caregivers would be able to spot trends and find new aspects of medical treatment that were previously difficult to comprehend and use [52]. [53] reported that IoT devices and systems can also assist medical practitioners in making more informed medical decisions and providing better patient care. Data could be collected without a physical examination using the IoT devices like linked medical sensors. Remote health monitoring is possible through wearable IoT devices such as falls-detection smart belts [54], movement detection sensor socks [55], vital signs collection smart wristwatches [56], and smart tablets or tiny swallowable sensors [57] that give data on a patient's stomach contents. Furthermore, caregivers can accurately monitor physical activity, vital signs, and other factors that might help them alter treatment regimens or intervene in other ways [58]. Having highlighted the capabilities of IoT in the healthcare sector, integrating it (IoT) into the Nigerian healthcare system would certainly enhance the quality of healthcare.

E. Research Question 5: What Dangers Exist while Utilising IoT in the Nigerian healthcare system?

This section examines the threats and dangers of the deployment of IoT in the Nigerian healthcare system. According to [59], the core threat to adopting IoT in the Nigerian healthcare industry is privacy and security problems. The patient data that is stored and processed over the Internet is very sensitive and valuable, so IoT security is necessary to protect this data from unauthorized access. A minor change in the value of critical metrics gathered by medical equipment such as glucose meters or pulse oxymeters, for example, might have a catastrophic impact on how patient care and drug doses are given [60]. [61] added that if hackers get control of medical equipment, they may change their functioning modes and transform them into lethal weapons. A bad but plausible possibility is breaking into a hospital network and accessing other medical devices with a single device.

As a result, a danger may emerge from a device brought in by patients or clients and connected to a guest network, which the organization's IT team may be unaware of [62]. The research of [63] reported that antivirus software and traditional firewalls are insufficient to provide effective security; as such, healthcare organizations must devise new methods of detecting threats both known and unknown.

Furthermore, [64] inform that outdated devices and convergence concerns make healthcare IoT security even more difficult. Replacement of a piece of a medical device can be costly for a healthcare organization. Such equipment, which has been in use for decades, may not conform with contemporary security regulations and standards, making it an ideal target for an attack.

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The Nigerian healthcare sector is yet to develop and has faced numerous setbacks. Surveillance systems are ineffective and unsuitable, with no tracking system to monitor the outbreaks of communicable disease, chemical poisoning, and bioterrorism, among others. A system solidly anchored in regular monitoring and medical intelligence as the pillar of the healthcare industry, as well as competent management coupled with robust leadership principles, are required to achieve success in the Nigerian healthcare system in this modern era. Integrating IoT into the Nigerian healthcare sector would make such a system a reality. The recommendations made in this study may apply to other countries that face similar challenges.

B. Recommendations

Adequate Management Information System (MIS) as the first line of approach to constructing the Nigerian health care system using IoT can prevent faults in the system. Of course, other barriers prevent the adoption and implementation of IoT in the Nigerian healthcare system, such as requirements for constant power supply and a high-speed Internet connection. In contrast, the major threat is related to privacy and security problems. However, the benefits of integrating IoT in the Nigerian healthcare system are enormous, including reduced costs, easy access to a patient's records irrespective of time and location, enhanced illness management, improved treatment outcomes, reduced caregivers and health facilities mistakes, and assistance in making intelligent decisions or recommendations based on available data. These benefits have outweighed the barriers and threats. As such, we suggest the following:

- To address the problem of shortage of power supply, the Nigerian government should partner with Power Holding Companies of Nigeria (PHCN) to ensure a steady supply of electricity throughout the country.
- To address the problem of poor Internet connection, the Nigerian government should collaborate with Internet Service Providers (ISPs) companies to provide reliable Internet connections across the country.
- To address the privacy and security problem, the Nigerian government should partner with healthcare stakeholders and cybersecurity experts to provide guidelines (best practices) to address the issues of privacy and security in the Nigerian healthcare industry.

If these problems are addressed, we strongly recommend the adoption and implementation of IoT in the Nigerian healthcare system, which has highlighted the benefits. This development would greatly enhance quality healthcare in the Nigerian healthcare industry.

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